

Temporal PCB-Concentration Trends With Time Varying Decay Rates In Carp And Smallmouth Bass Fillets

Kalamazoo River And Portage Creek, Mi.

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Introduction

- The National Research Council has proposed temporal reduction of fish tissue concentrations as an indicator of the effectiveness of natural attenuation (NRC 2001).
- Forecasts of natural attenuation are often expressed as first order decay rates.
- As immediate effects of source control are realized and natural attenuation becomes the dominant factor affecting reductions, decay rates are expected to slow with time.

Problem Statement

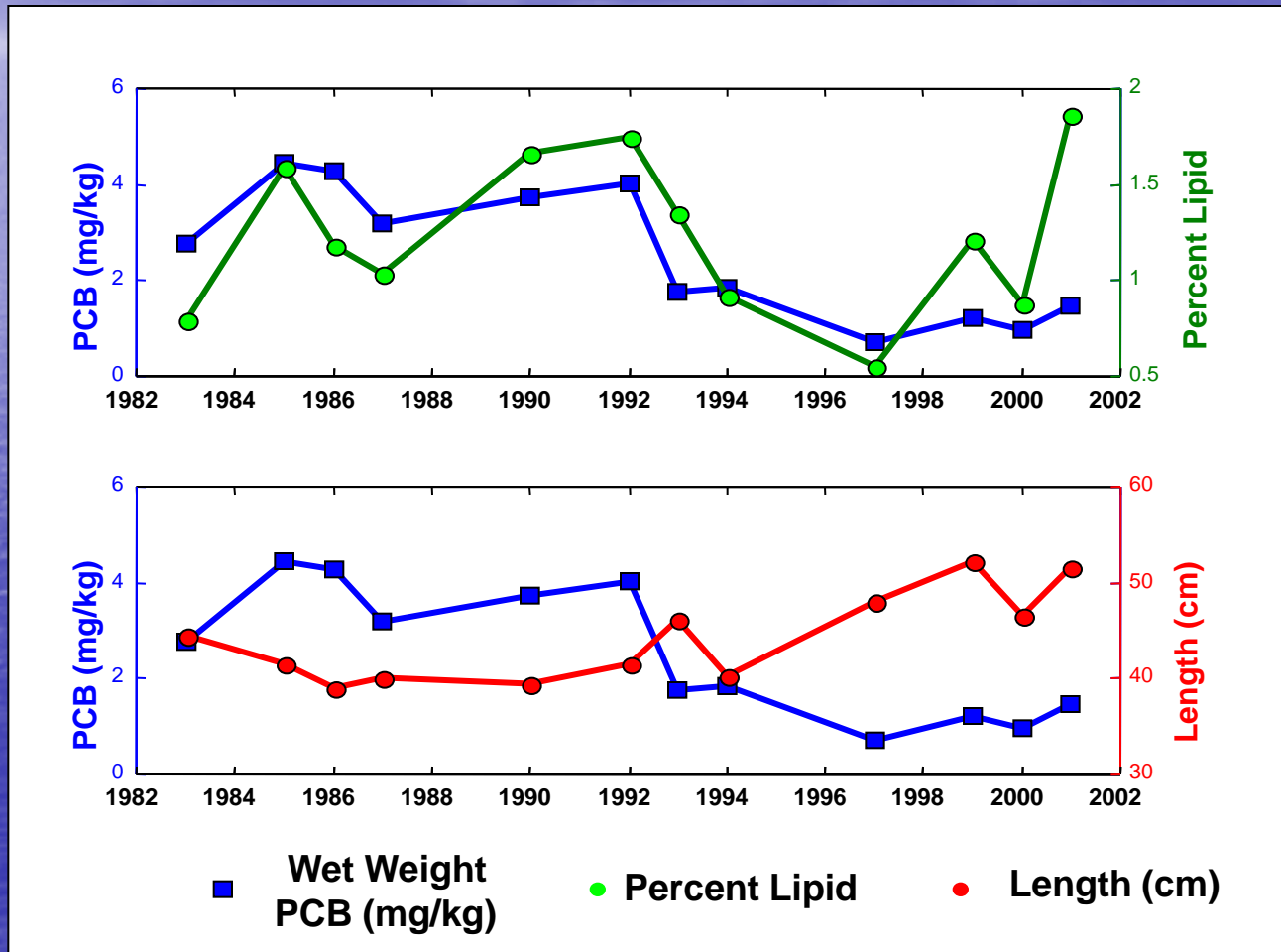
- Stow et al (1999) found that PCB concentration in salmonids from Lake Michigan are higher than would have been expected under first order decay .
- They proposed the mixed order model as a more flexible alternative for forecasting near-term trends.
- We fit the mixed order model to lipid- and length-adjusted PCB concentrations to forecast PCB concentration in smallmouth bass and common carp.
 - Parameters were estimated using maximum likelihood assuming a lognormal error distribution.

$$\frac{dC}{dt} = k C_t^\theta \qquad C_{MO}(t) = \left[C_P^\theta - k \cdot (t - t_P) \cdot (\theta) \right]^{\frac{1}{(\theta)}}$$

Problem Statement.....continued

- Fish were collected from the Kalamazoo River and Portage Creek from 1983 through 2001.
- PCB concentration in carp and smallmouth bass fillets were found to vary with:
 - Lipid content
 - Exposure duration (indexed by length)
 - Sampling location
- Associations between PCB, length and lipid also varied with time.
 - These temporal interactions indicate that decay rates vary with lipid-content and fish length.

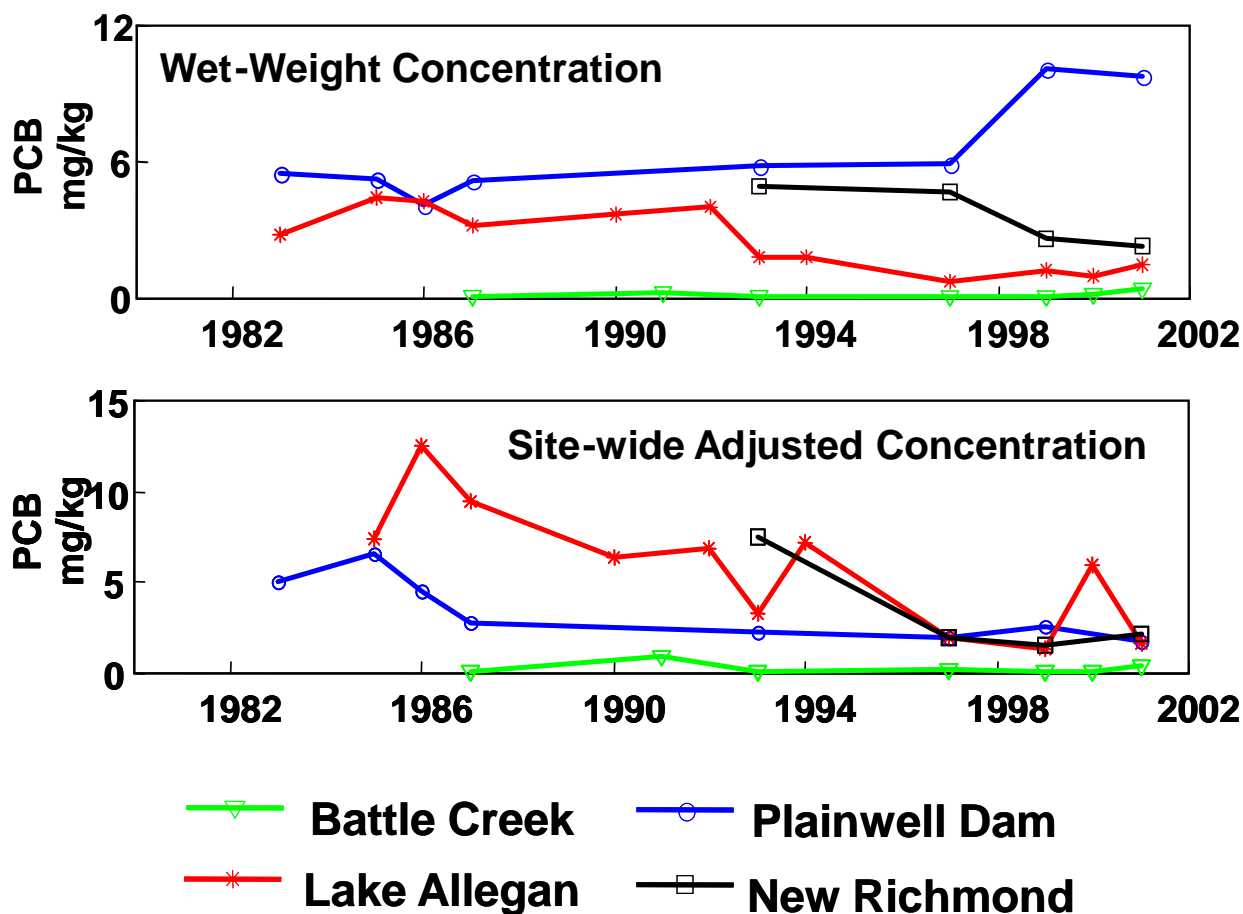
TEMPORAL TRENDS IN AVERAGE LENGTH, LIPID AND WET-WEIGHT PCB IN CARP FILLETS AT LAKE ALLEGAN



Methods.....continued

- We adjusted PCB concentration in each species in two ways:
 - Based on representative length and lipid-content for fish **among** all sampling locations.
 - Based on representative length and lipid-content for fish **within** each sampling location.
- The Site-Wide adjustment method was appropriate for among site comparisons of site conditions to which fish are exposed.
- The Within-Site adjustment method was appropriate for within site comparisons among years.
 - Within-site adjusted concentrations represent the exposure that human fish consumers could expect.


Wet-weight vs. Adjusted PCB Concentration in Carp Fillets at Kalamazoo River



Statistical Inference

$$\mathbf{R} = \mathbf{C} - \mathbf{X}\hat{\boldsymbol{\beta}}$$

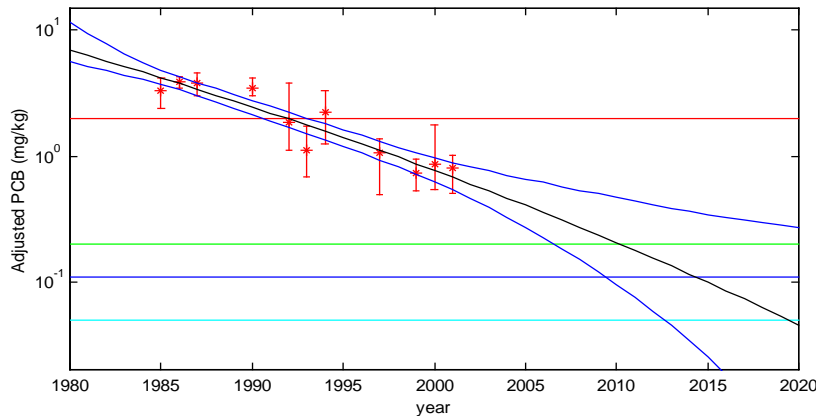
Bootstrap
Resample

- 
- Calculate residuals from multiple regression between concentration length and lipid.

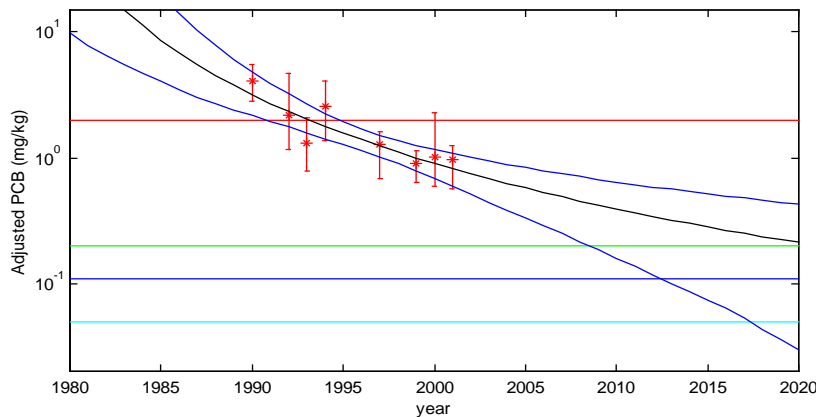
- Adjust concentrations. $\mathbf{C}_{adjusted} = \exp(R + \mathbf{X}_{rep}\hat{\boldsymbol{\beta}})$

- 
- Fit MO model to adjusted concentration. $\mathbf{C}(t)_{adjusted} = MO(t)$

MO Model for Lake Allegan Carp Fillets



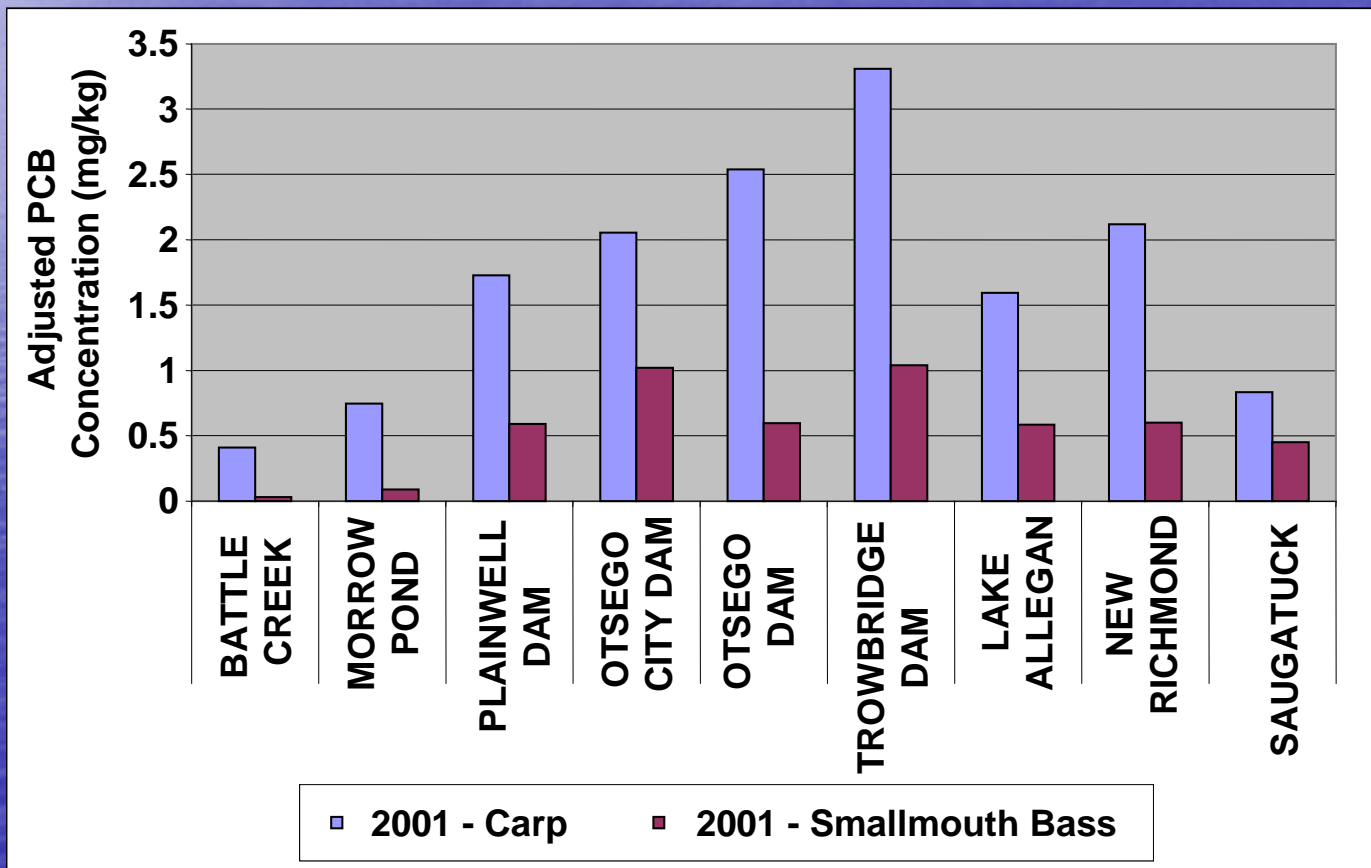
All data 1983-2001.
Decay rate similar to
exponential.



All data 1990-2001.
Decay rate slower than
exponential.

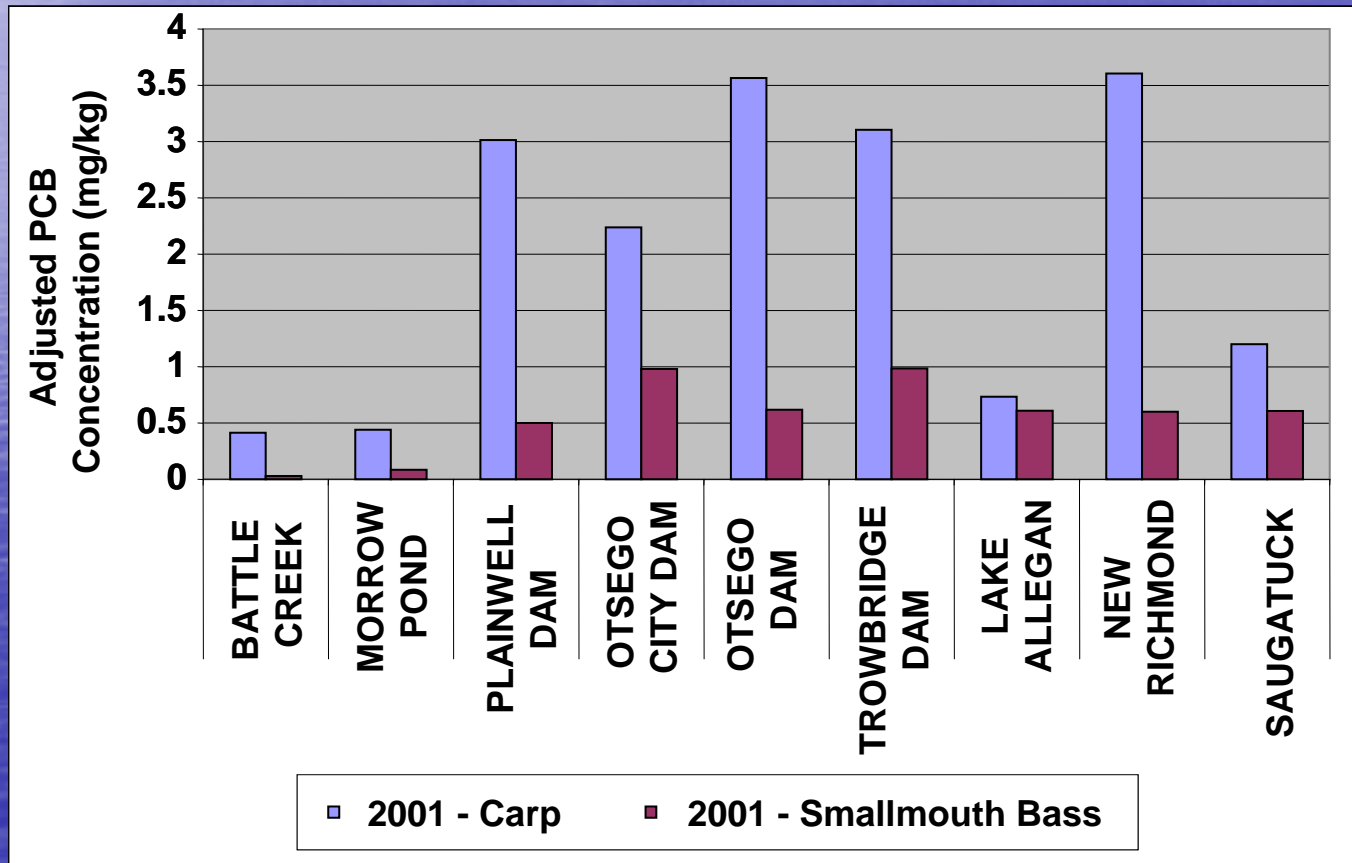
Site-wide Length- And Lipid-adjusted PCB Concentration In Fillets In 2001

Index To Exposure That Fish Receive

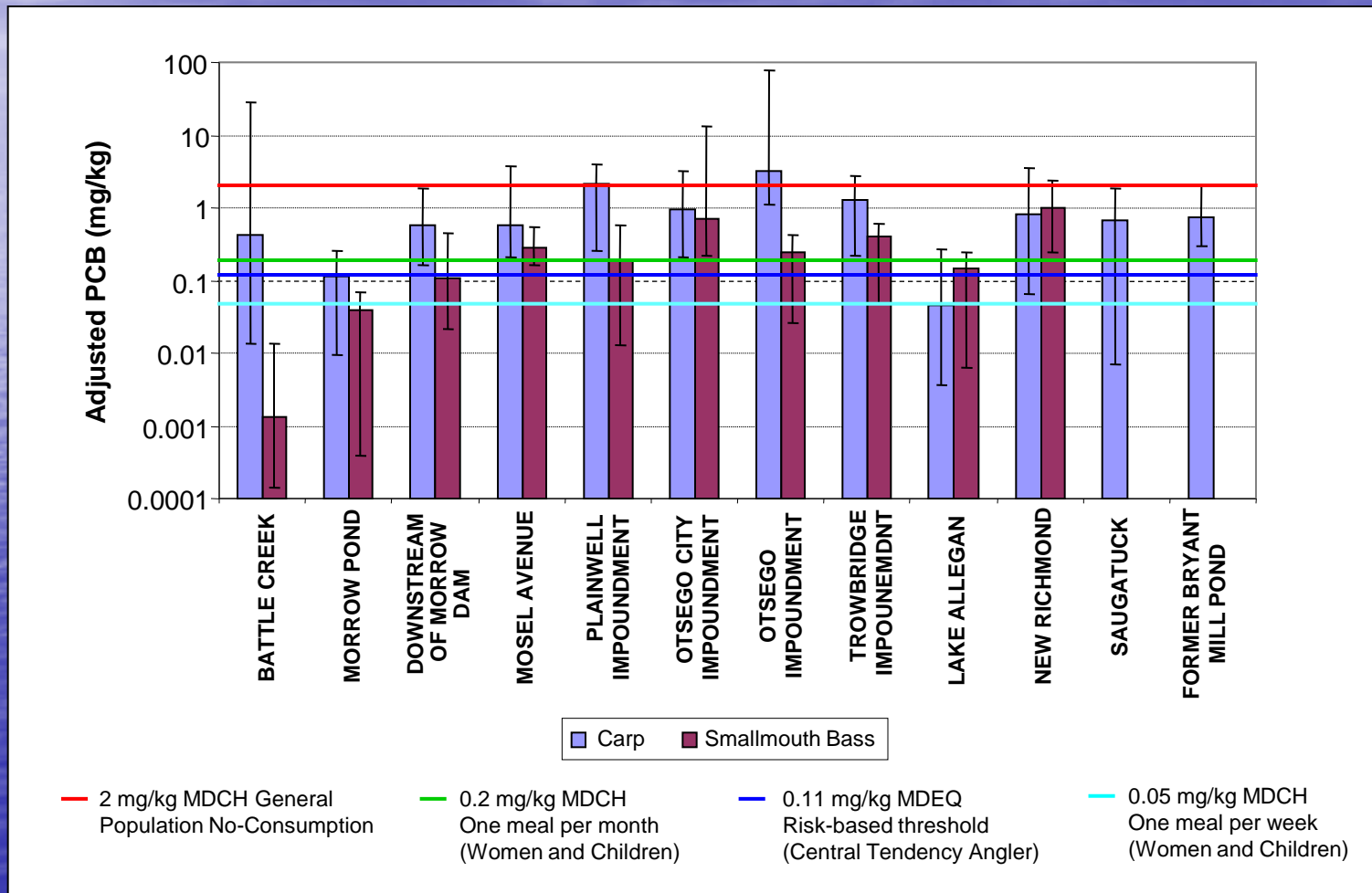


LENGTH- AND LIPID-ADJUSTED (ABSA-SPECIFIC) PCB CONCENTRATION In FILLETS IN 2001

Expected Exposure For Fish Consumers



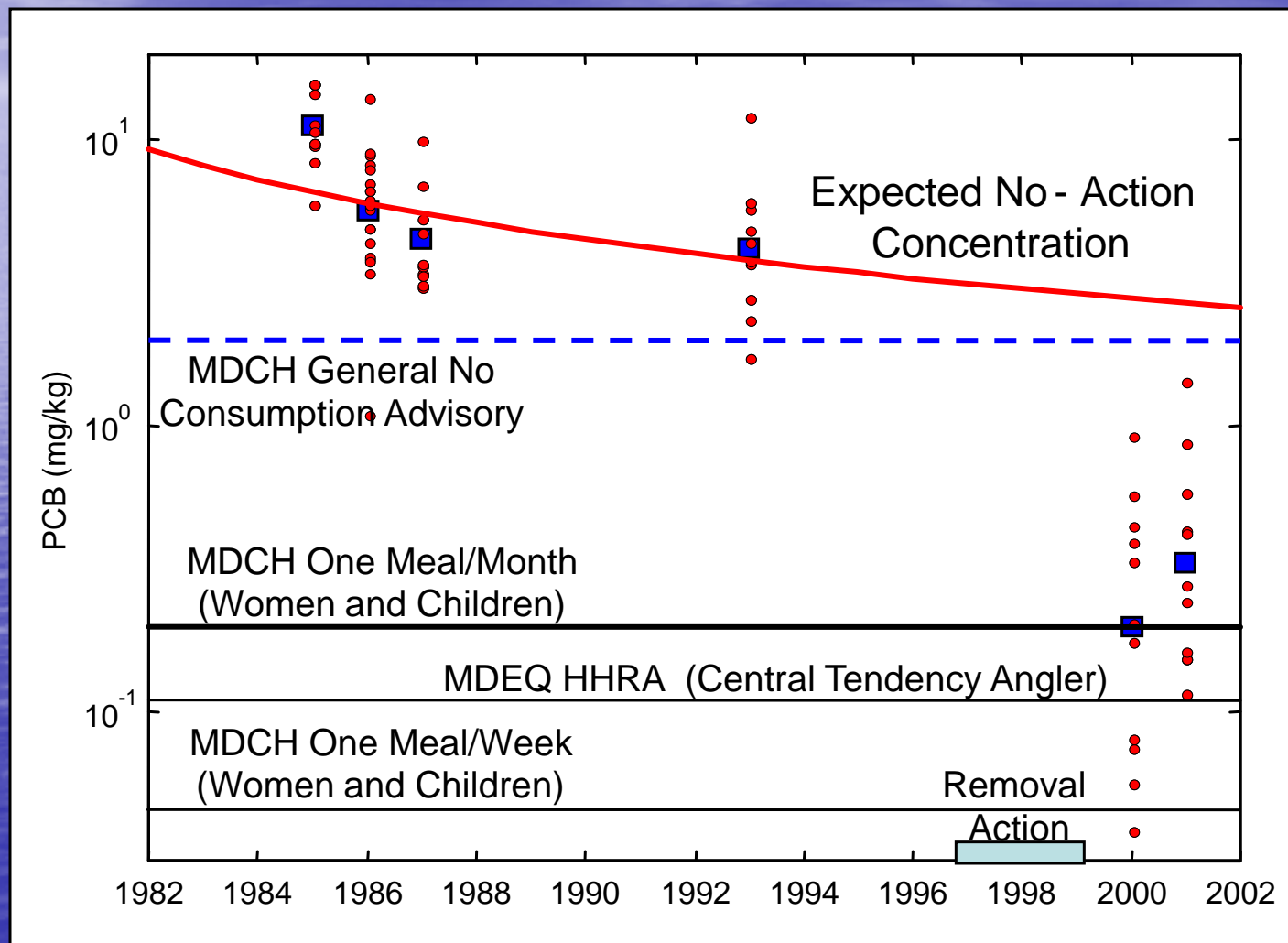
Projected PCB Concentration In Carp And Smallmouth Bass Fillets In 2020



Preliminary Effect of Sediment Removal

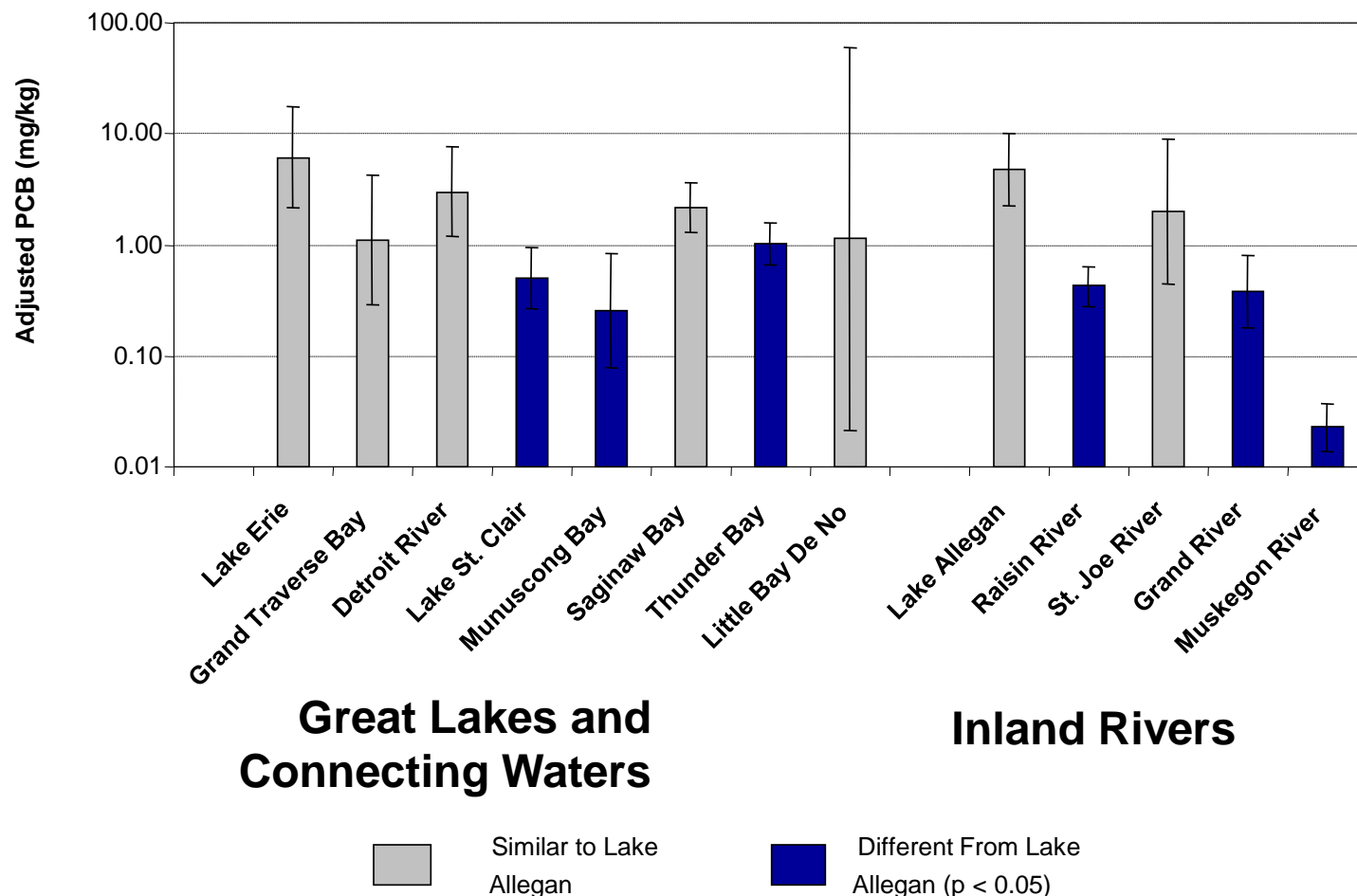
- A time critical removal action was conducted at the former Bryant Mill Pond on Portage Creek in the fall of 1998 and winter of 1999.
- PCB concentrations in carp fillets captured in 2001 and 2002 are an order of magnitude lower than projected concentrations for 2020.

Adjusted PCB Concentration In Carp Fillets At Bryant Mill Pond



Regional Comparisons

Adjusted PCB in Whole Body Carp 1997-1999



Conclusions

- Wet-weight or lipid normalized PCB concentrations may not provide an accurate picture of PCB trends in biota at the Kalamazoo River and Portage Creek.
- The MO model provides a flexible alternative to first order decay assumptions.
- Bootstrap resampling provided a robust method to simultaneously account for uncertainty due to data adjustment, and MO parameter estimation.

Conclusions.....continued

- After adjusting for covariation with length and lipid-content, carp from Lake Allegan had the highest PCB concentrations of any of the inland rivers monitored in Michigan from 1997-1999.
- Carp exposure to PCB in the Kalamazoo River were similar to that found in the lower great lakes in 1997-1999.
- Sediment removal at former Bryant Mill Pond may have reduced current Carp PCB concentrations to levels below that expected in 2020 under natural attenuation.

References

- NRC 2001. *A Risk-Management Strategy for PCB-Contaminated Sediments*. Committee on Remediation of PCB-Contaminated Sediments, Board on Environmental Studies and Toxicology, Division on Life and Earth Studies, National Research Council, National Academy Press, Washington D.C.
- Stow, C.A., Jackson, L.J., and S.R. Carpenter. 1999. A mixed-order model to assess contaminant declines. *Environmental Monitoring and Assessment*. 55:435-444.